

Claims

[c1] 1. A diode structure, comprising:

a substrate layer comprising a semiconductor material and first doping impurities with a first charge polarity; a first layer having an opening, the first layer being on top of and in direct physical contact with the substrate layer, the first layer comprising the semiconductor material and second doping impurities with a second charge polarity, the second charge polarity being opposite to the first charge polarity, the opening comprising the semiconductor material but not comprising the second doping impurities;

a second layer being on top of and in direct physical contact with the first layer, the second layer comprising the semiconductor material and third doping impurities with the second charge polarity, the first layer having a higher doping concentration than the second layer; and an electrode structure being on top of and in direct physical contact with the second layer, the electrode structure including at least an anode and a cathode of the diode structure.

[c2] 2. The structure of claim 1, wherein the electrode struc-

ture is in direct physical contact with the first layer.

- [c3] 3. The structure of claim 1, wherein the anode of the diode structure is doped with the first charge polarity and the cathode of the diode structure is doped with the second charge polarity.
- [c4] 4. The structure of claim 1, wherein the opening is formed with a predetermined size configured to achieve a given value of the breakdown voltage of the diode structure.
- [c5] 5. The structure of claim 1, wherein at least one STI (Shallow Trench Isolation) region is formed between the anode and the cathode.
- [c6] 6. The structure of claim 1, further comprising a plurality of deep trenches isolating the diode structure.
- [c7] 7. The structure of claim 1, wherein the first layer is configured to expand and fill the opening at high temperature.
- [c8] 8. The structure of claim 1, wherein the first doping impurities are P type, and the second and third doping impurities are N type.
- [c9] 9. A method for forming a diode structure, the method comprising the steps of:

providing a substrate comprising a semiconductor material and first doping impurities with a first charge polarity;

implanting in the substrate second doping impurities with a second charge polarity to form a first layer with an opening, the opening comprising the semiconductor material and not comprising the second doping impurities;

implanting in the substrate third doping impurities with the second charge polarity to form a second layer on top of and in direct physical contact with the first layer, the first layer having a higher doping concentration than the second layer; and

forming an electrode structure on top of and in direct physical contact with the second layer, the electrode structure including at least an anode and a cathode.

[c10] 10. The method of claim 9, further comprising the step of extending the electrode structure down in direct physical contact with the first layer.

[c11] 11. The method of claim 9, wherein the anode is doped with the first charge polarity and the cathode is doped with the second charge polarity.

[c12] 12. The method of claim 9, wherein the step of implanting in the substrate the second doping impurities com-

prises the step of forming the opening at a predetermined size configured to achieve a given breakdown voltage of the diode structure.

- [c13] 13. The method of claim 9, further comprising the step of forming at least one STI (Shallow Trench Isolation) region between the anode and the cathode.
- [c14] 14. The method of claim 9, further comprising the step of forming a plurality of deep trenches isolating the diode structure.
- [c15] 15. The method of claim 9, wherein the step of implanting in the substrate the second doping impurities comprises the step of expanding the first layer at high temperature to fill the opening.
- [c16] 16. The method of claim 9, wherein the first doping impurities are P type, and the second and third doping impurities are N type.
- [c17] 17. A diode structure, comprising:
 - a substrate layer comprising a semiconductor material;
 - a first layer having an opening, the first layer being on top of and in direct physical contact with the substrate layer, the first layer comprising the semiconductor material and first doping impurities with a first charge polarity, the opening comprising the semiconductor material

and not comprising the first doping impurities; and a second layer being on top of the first layer, the second layer comprising the semiconductor material and second doping impurities with a second charge polarity, the second charge polarity being opposite to the first charge polarity.

- [c18] 18. The diode structure of claim 17, further comprising a third layer extending from the surface of the substrate down in direct physical contact with the first layer, the third layer comprising the semiconductor material and third doping impurities with the first charge polarity and being separate from the second layer.
- [c19] 19. The diode structure of claim 18, wherein the second layer and the third layer are used as two electrodes of the diode structure.
- [c20] 20. The diode structure of claim 17, wherein the opening is formed with a predetermined size configured to achieve a given value of the breakdown voltage of the diode structure.